REMARKS

Claims 1-17 are pending in the application. Claims 1-17 are rejected.

Priority

A new Declaration is submitted herewith claiming priority from Chinese application 00130335.X filed on October 27, 2000. Acknowledgment is respectfully submitted.

Drawings

Submitted are substitute formal Drawing figures 1-11 on 5 sheets. The drawing quality has been improved. There are no changes and no new matter. It is respectfully requested the rejection be withdrawn.

Specification

Enclosed is a mark-up version of the specification showing changes made therein. Also enclosed is a clean version of the specification as a substitute for the original. The clean version incorporates the changes shown in the mark-up version. The English phraseology has been corrected as well as typographical errors. No new matter is entered.

With regard for the antecedent bases issues with claims 10 and 11, it is respectfully submitted the copy queues are supported for example on pages 15-17 of the substitute specification.

It is respectfully requested the specification objections be withdrawn.

Claim Objections

Claims 1, 2, 9, 13, 16 and 17 are objected to. These claims have been amended to correct the informalities and typographical errors.

Claim Rejections

In the claims the Examiner has rejected claims 1-17 under 35 U.S.C. § 112, second paragraph, as being indefinite. Claims 1-17 have been amended to clarify the claimed invention. The claims have not been narrowed in that regard. It is respectfully requested the rejections be withdrawn.

With regard to the prior art rejections claims 1-4 under 35 U.S.C. § 103(a) are rejected as being unpatentable over Bao "Performance evaluation of TCP/RLP protocol stack over CDMA wireless link" in view of Jeon et al. (Improved Selective Repeat ARQ Scheme for Mobile Multimedia Communications".

It appears that the Bao reference is relied upon to teach and describe applicant's claim 1 except for the transmitting of multiple copies in response to a single NAK. The Office Action asserts Jeon shows the transmitting of multiple copies of the NAK packet in the receipt of a single NAK.

However it is respectfully submitted that none of the references describe re-transmitting multiple copies of the specific data packet with a delay inserted between each consecutive copy.

Regarding the NAK-based retransmission disclosed in the documents by Bao and Jeon, the examiner argues that the linear or exponential generation of multi-copy of the retransmission packets is disclosed and it is well known to insert a delay for retransmission of packets depending on the condition of channel in the wireless communication system.

However, as described below the claims recited that the delay is inserted for retransmission of the multiple copies of the specific data packet. The prior art is characterized by the technology that the packets are transmitted after insertion of a delay for the original transmission, whereas the claimed invention proposes a novel technology that a delay is clearly

inserted among a plurality of retransmission packets when a plurality of packets are transmitted during the retransmission.

This novel technique is not disclosed in the documents by Bao and Jeon.

The reference Bao basically summarizes a relationship between parameters and throughputs by simulating the retransmission mechanism of TCP and retransmission of RLP (Radio Link Protocol).

Cited in the Office Action is the content of Chapter 2 "RLP and its link performance". This content discloses that RLP is the NAK-based Selective repeat protocol, transmission of NAK is performed using a parameter set based on a certain timer during the transmission of NAK, and transmission of packets is performed linearly until the number of packets of NAK reaches the maximum specified value of the system.

Wha Sook Jeon, "Improved Selective repeat ARQ scheme for Mobile Multimedia Communications" proposes improvement in the Selective Repeat ARQ as the improvement in RLP used for data communication of CDMA and performs a simulation of this proposal.

Jeon discloses that the NAK-based protocol is employed for the Selective repeat protocol and transmission is performed until the number of NAK packets reaches the maximum number of times of retransmission specified exponentially for the system such as 2, 4, 8, ...

<u>Comparison of Present Claims with Cited Documents, and Discussion</u>

a) Structure not disclosed in the cited document

The present claims uses the NAK-based Selective Repeat ARQ but is characterized in the retransmission method of NAK.

Characteristics of the present invention are illustrated, for example, in Fig. 2 or Fig. 3 of the substitute specification.

These figures illustrate a method (D-Linear-MCR) in which the number of NAK packets to be re-transmitted increases linearly as 2, 3, 4, … depending on the number of times of retransmission and a method (D-Expo-MCR) in which the number of NAK packets increases exponentially as 2, 4, 8, … .

In contrast to the cited references applicant's claims recite <u>a certain delay time (d) is inserted between the NAK packets</u> generated in the same period at the time of transmitting a plurality of copied NAK packets.

Insertion of delay between a plurality of NAK packets to be re-transmitted is basically performed to continuously transmit the NAK packets 2, 3, 4, … or 2, 4, 8, … even when the NAK packets are increased up to 2, 3, 4, … or 2, 4, 8, … in the prior art against deterioration in the transmission environment like a burst in the wireless system. Therefore, there is a rise of possibility for transmission in which a plurality of NAK packets cannot be transmitted completely under the condition that the transmission environment is deteriorated like a burst. In the present invention, even in the case of transmitting the copied data packets, such data packets can be transmitted after recovery of the transmission environment deteriorated like a bust by clearly inserting a delay (d) among a plurality of copied packets.

Namely, for example, in the case of transmitting two retransmission data, it is possible to expect the effect for improving the possibility for success of transmission by transmitting the second data after recovery of environment even if the first packet cannot be transmitted in the deteriorated transmission environment.

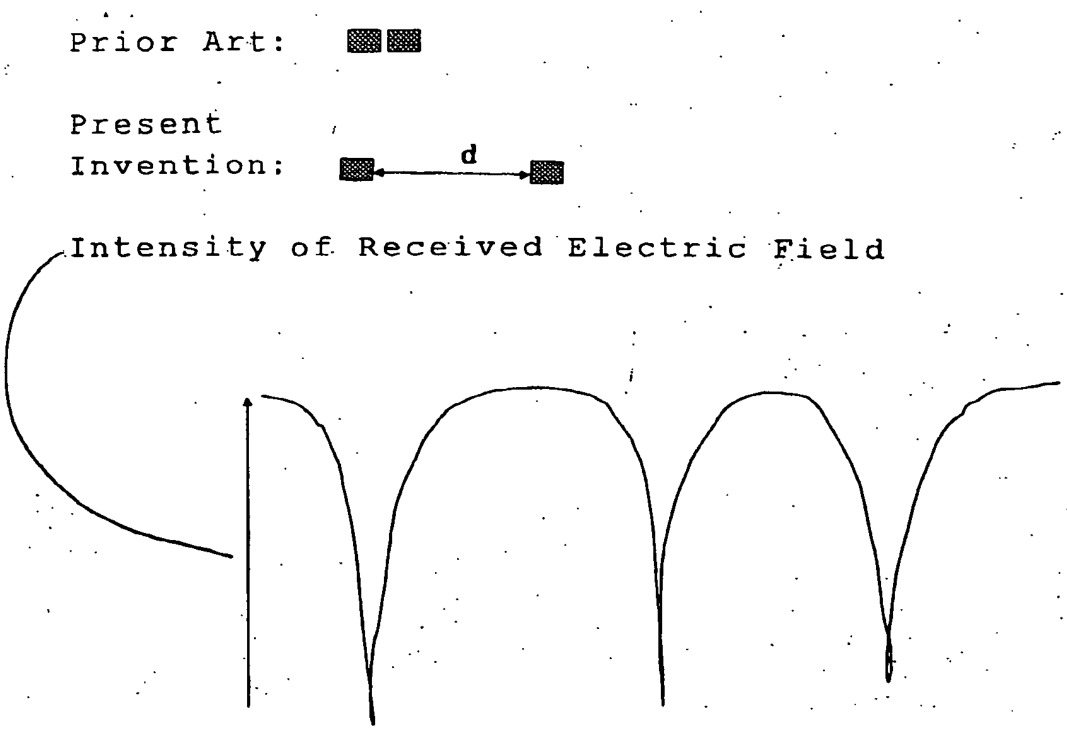

Fig. 1: Simplified Principle Diagram of Present Invention

Fig. 1 illustrates the principle for complementarily describing Fig. 1 or Fig. 2 of the specification, although not described in the specification. The lower part illustrates intensity fo the received electric field in the transmitting section, while the lower part illustrates a method of transmitting the retransmission packets. Moreover, the first failure in transmission is not illustrated.

From the above figure, in the method of the prior art, a couple of copied data are generated in the second transmission and these two packets are transmitted continuously. In this case, when the intensity of received electric field in the transmission environment is as low as illustrated in Fig. 1 during transmission of these two packets, these packets are failed in the transmission. Moreover, when in the case of linear transmission, three packets are transmitted after insertion of a certain period, while four packets are further transmitted in the case of

exponential transmission by copying such packets for transmission by copying such packets for retransmission.

In applicant's claimed invention, as illustrated at the lower part of the prior art method, a delay (d) is inserted clearly between two generated copied packets for attempting retransmission. Accordingly, when the transmission environment is recovered quicker than the inserted delay (d), data can be transmitted correctly with the second retransmission packet of the first transmitting operation transmitted after insertion of the delay (d) . As a result, improvement in the throughput of the system as a whole and. shortening of the delay time can be realized.

For at least the foregoing reasons it is respectfully submitted claims 1-4 are different from and non-obvious in view of the cited references.

Regarding the Claims 5 to 14:

With regard to claims 5-14 the Office Action relies on the Bao and Jeon references, and further recites the Kawabata et al. reference.

Claim 6 utilizes the interleaving technology for inserting a delay among the retransmission packets. This interleaving technology used for error correction is introduced because the error correction capability is lowered if a plurality of packets are simultaneously lost during error correction.

In other words, this interleaving technology is required to change the sequence of retransmission packets copied for generating a delay described above. Accordingly, it is respectfully submitted that claim 6 is also allowable as claim 1.

We also think that since the claims 7 to 9 are dependent claims of the claim 6, and likewise in condition for allowance. Claim 10 is the depending claim of claim 5 and claim 1 and

the claim 5 and likewise in condition for allowance. The remaining dependent claims although each includes additional features, should be allowed because the base claim is allowable Regarding Claim 15 rejected by by Bao, Jeon and Kawabata:

In addition to the delay inserted among a plurality of copied retransmission packets (a plurality of packets are simultaneously transmitted continuously in the ordinary ARQ), this claim describes the technique related to Fig. 4 and Fig. 5 of the specification.

In the prior art, the priority of Queue for ordinary retransmission is generally higher than that of the transmission Queue and if data is still left in the retransmission Queue, such data is transmitted first. But, since a delay is inserted among a plurality of retransmission packets to be retransmitted in the present invention, the ordinary transmission packets are transmitted from the side of Transmission Queue when the packets to be retransmitted are still left as illustrated in Fig. 5 within the delayed period inserted to the packets for retransmission. This mechanism is not described in the documents written by Bao, Jeon and Kawabata.

Accordingly, it is submitted that claim 15 should be allowed.

5. Regarding Claim 16:

This claim describes a method of preparing for a plurality of queues and inserting a delay among a plurality of packets retransmitted depending on the queue length. Moreover, in this method, polling is performed even when data exists or does not exist in this queue and nothing is transmitted when the data does not exist in the queue. This method is not described in any document among those by Bao, Jeon and Kawabata.

6. Regarding Claim 17:

In this claim, a delay is inserted among a plurality of packets copied transmitted in the predetermined intervals. As discussed above, this technique is not yet disclosed in the documents written by Bao, Jeon, and Kawabata.

In view of the remarks set forth above, this application is in condition for allowance which action is respectfully requested. However, if for any reason the Examiner should consider this application not to be in condition for allowance, the Examiner is respectfully requested to telephone the undersigned attorney at the number listed below prior to issuing a further Action.

Any fee due with this paper may be charged to Deposit Account No. 50-1290.

Respectfully submitted,

Brian S. Myers
Reg. No. 46,947

CUSTOMER NUMBER 026304
Telephone: (212) 940-8703
Fax: (212) 940-8986 or 8987
Docket No.: FUJB 18.867 (100794-00084)
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Attorney Docket No.: FUJB 18.867 (100794-00084)

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

Inventor:	ZHISHENG NIU, et al.
Confirmation No.:	6373
Serial No.:	09/933,893
Filed:	August 21, 2001
Title:	METHOD FOR RETRANSMISSION OF LOST PACKET…
Examiner:	MARSHALL S. ENG
Group Art Unit:	2133

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MARKED-UP VERSION OF SPECIFICATION

A Method for Retransmission of Lost Packet in Fading Channels

BACKGROUND OF THE INVENTION

Field of the Invention

The invention concerns ~~one kind of~~ an effective and reliable transmission technique~~. More precisely, it concerns~~ with a scheme for retransmission of a lost packet in correlated fading channels.

Prior Art

At present, Internet and mobile communication technology has ~~greatly~~ development ~~and there is~~ with a growing trend to converge them, ~~it requires~~ thus requiring mobile communication service, originally providing voice transmission service only, to also provide data transmission service ~~at the same time~~. ~~As the~~ Because of correlated fading characteristic of a wireless channel, data ~~packet~~ packets can be lost, so there is a problem of unreliable transmission. Reliable link layer ~~protocol~~ protocols, such as Automatic Repeat Request (ARQ), ~~is one kind of a~~ are one method to ~~solve~~ provide reliable transmission in an unreliable transmission system.

ARQ methods can be roughly classified into Stop-and-Wait (SW), Go-back-N (GN) and Selective Repeat (SR). Among them, SR-ARQ is the most efficient and has been widely used in practical mobile ~~system~~ systems, for example IS-99 (TIA/EIA/IS-99, "Data Services Option Standard for Wideband Spread Spectrum Digital Cellular System", 1955).

Figure 1 shows a working procedure of Selective Repeat (SR-ARQ). When the receiver sends back the Acknowledge (ACK) or Negative Acknowledge (NACK), the transmitter determines whether a specific data packet (for example #1) is lost or not, and makes ~~the~~ a selective retransmission ~~further~~. When the transmitter receives an ACK signal, it means the #1 packet has been received successfully, it is unnecessary to retransmit again. When the Transmitter receives a NACK signal, it means that the #1 packet has not been received successfully, it is a transmission failure, the packet is lost and it is necessary to retransmit. When there is retransmission, each time only one copy of the lost #1 packet is retransmitted. The figure shows that after two times retransmission of #1 packet copy, it is received successfully. This means that in the traditional SR-ARQ scheme, when a packet is lost, only one copy of the lost packet is retransmitted each time. Obviously, the worse the environment of transmission, the more times ~~of~~ retransmission ~~are~~ is needed. In this case the data packet has a longer persistence time in the transmitter buffer~~, it~~ and will seriously decrease the quality of data service.

Naturally, when a data packet is lost, multiple copies of the lost data packet can be retransmitted each time. But in a mobile communication system, because of the instinctive burst error characteristics in correlated fading channels~~, on the one hand it leads~~ data packets are successively lost~~; on the other hand it is happened that,~~ and if multiple copies ~~of~~ are sent for each retransmission they will meet the same bad state of the fading channels at the same time[[,]] and the retransmission is failure, i.e. retransmission efficiency is low. Therefore, in correlated fading channels ~~how to decrease~~ the issue of decreasing the number of retransmissions ~~retransmission~~ and ~~to increase~~ increasing retransmission efficiency are two big problems needing consideration ~~needed to be considered at the same time~~.

SUMMARY OF THE INVENTION

It is an object of the invention to provide a retransmission method for lost packets in correlated fading channels~~, it~~ that will decrease the number of ~~retransmission~~ retransmissions and increase the efficiency of each retransmission ~~efficiency at the same time in correlated fading channels~~.

The above and other objects of the invention are implemented as follows. A retransmission method for lost packet in a fading channel is characterized in that: when the transmitter receives from a receiver ~~of~~ in a mobile communications system, a negative acknowledgement (NACK), which points to a specific data packet, multiple copies of the specific data packet will be retransmitted, ~~in the way that~~ wherein a delay is inserted between two consecutive copies ~~a delay is inserted~~.

The ~~multiple copies, the~~ number of multiple copies is acquired by calculation based on the number of current ~~retransmission~~ retransmissions of the specific ~~data packet, it is also~~ data packet. The number of copies is increased along with ~~the~~ an increase of the number of ~~retransmission~~ retransmissions.

In ~~on~~ one embodiment, the method of the present invention used to retransmit lost packets in a fading channel, includes ~~comprises~~ the following steps:

A. At least two queues are set in the transmitter, including a transmission queue and a retransmission queue;

B. New data packets, which will be transmitted, are stored in the transmission queue; the copies, the number of which are defined by current number of retransmission data packets, are stored in the retransmission queue;

C. It is determined whether the retransmission queue is in the state of empty or not, when the current retransmission queue is empty, with first-in-first-out principle, data packets in the transmission queue are transmitted; When the current retransmission queue is not empty, the data packet copies in the retransmission queue are transmitted with interleaving transmission;

D. The minimum value of time length of an interleaving retransmission interval is set by a timer, select one copy of every retransmission data packet from the retransmission queue, transmit them in every interleaving retransmission interval by the first-in-first-out principle; if before the end of a minimum value of interleaving retransmission interval time length, one copy of all data packets in the retransmission queue has been transmitted, then with the first-in-first-out principle, data packets in the transmission queue are transmitted until the end of the minimum value, set by the timer, of the interleaving retransmission interval time length. Then this interleaving retransmission interval will be ended and the next one will be started; if before the end of the minimum value of the interleaving retransmission interval time length, one copy of all data packets in the retransmission queue has been transmitted and the transmission queue is empty, then transmission stops until the end of the minimum value, set by the timer, of the interleaving retransmission interval time length. Then, this interleaving retransmission

interval will be ended and the next one will be started; when an interleaving retransmission interval is ended and the retransmission queue is empty, then data packets in the transmission queue are transmitted by the first-in-first-out principle.

Another ~~In another~~ embodiment ~~the method of the invention used~~ to retransmit a lost packet in a fading channel includes ~~comprises~~ the following steps:

A. At least two queues are set in the transmitter, including a transmission queue and a retransmission queue;

B. New data packets, which will be transmitted, are stored in the transmission queue; ~~the~~ copies, the number of which ~~are~~ is defined by current number of retransmission data packet, are stored in the retransmission queue;

C. It is determined whether the current retransmission queue is in the state of empty or not, when the current retransmission queue is empty, with the first-in-first-out principle, data packets in the transmission queue are transmitted; when the current retransmission queue is not empty, the data packet copies in the retransmission queue are transmitted with multiple queue polling transmission;

D. Setting copy queues with a sequence number, each copy queue includes one copy of different data packet. Starting from the first copy queue, with the first-in- first-out principle, every data packet copy in each copy queue is transmitted in sequence.

Only after sending out all the copies in one queue, the next copy queue transmission can be started until the final copy queue. When all the copy queues are empty, then the polling transmission is ended and the transmission of the said transmission queue is started.

According to yet another embodiment ~~the method of the invention used to retransmit lost packets in fading channel, comprises the steps in which~~ a transceiver, in a mobile communication system, transmits a packet to a receiver or provides a plurality of copies of a special packet, when the transceiver receives information which indicates that the receiver does not receive the specific packet, the transceiver retransmits the specific packet in order at a predetermined interval.

In ~~an~~ another embodiment, the method of the invention used to retransmit a lost packet in a fading channel, is a retransmission method with multiple copies plus delay. By ~~With~~ transmitting multiple copies of a lost data packet for each retransmission, it is different ~~with~~ than the traditional SR-ARQ, in which ~~their~~ only one copy is sent, therefore the success probability of each retransmission is ~~increase~~ increased. At the same time, an adequate delay is inserted between two consecutive copies of the same lost data packet when transmitting multiple copies of a specific lost data packet. In this way the probability [[,]] of meeting [[in]] the bad state of the fading channel for multiple copies of the one lost packet, is ~~decrease~~ decreased, i. e. success probability of each retransmission is ~~increase~~ increased. Therefore efficiency of retransmission is increase effectively and number of retransmission is decrease.

Following combines embodiment and appended figures to further describe technology of the invention.

BRIEF DESCRIPTION OF THE DRAWINGS

Figure 1 is a schematic diagram of a typical SR-ARQ working procedure;

Figure 2 is a diagram to define ~~copy number of~~ the number of copies for each retransmission ~~with~~ by a linear increasing scheme according to the invention;

Figure 3 is a diagram to define ~~copy number of~~ the number of copies for each retransmission ~~with~~ by an exponential increasing scheme according to the invention;

Figure 4 is a schematic diagram of an interleaving procedure within an interleaving retransmission scheme according to the invention;

Figure 5 is a diagram~~, which is the first implementing procedure~~ representing an implementation scheme for an interleaving retransmission scheme according to the invention;

Figure 6 is a diagram, which is ~~the second implementing procedure~~ another implementation scheme for an interleaving retransmission scheme according to the invention;

Figure 7 is an analysis diagram of effectiveness for an interleaving retransmission scheme according to the invention;

Figures 8 - 10 ~~shows~~ show examples of the emulated relationship curve diagrams between Delay Time with Effective Throughput, Delay Time with a Mean of the Number of Retransmissions and Delay Time with Variation of the Number of Retransmissions, respectively; and

Figure 11 shows an example of the emulated curve diagram of the improvement of transmission performance after using the invention scheme.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

Figure 1 has been mentioned above, it would not be repeated.

Referring to figure 2 and figure 3, these figures show two schemes of the invention respectively, which define the specific number of lost data copies for each retransmission.

They include a linear increase scheme, as shown in figure 2, and an exponential increase scheme, as shown in figure 3, they are all related to the number of retransmissions ~~retransmission~~ of this (current) time. The linear ~~Linear~~ increase scheme can be summarized as the number of copies ~~number~~ for i^{th} retransmission is i+1. The exponential ~~Exponential~~ increase scheme can be summarized as the number of copies ~~number~~ for i^{th} retransmission is 2^i.

In figure 2, when a transmitter receives a NACK signal [[at]] the first time for # number data packet, it retransmits two copies of # number data packet, and inserts a delay d between two consecutive copies of each # number data packet. When the transmitter receives a NACK signal [[at]] the second time for # number data packet, it retransmits three copies of # number data packet, and inserts a delay d between two consecutive copies of each # number data packet; and so on. If the transmitter receives a NACK signal [[at]] the third time for # number data packet, it will retransmit four copies of # number data packet, and will insert a delay d between two consecutive copies of each # number data packet (this has not been shown in the figure). Figure 2 shows at the second time of retransmission, its third copy is received correctly.

In figure 3, when a transmitter receives a NACK signal [[at]] the first time for # number data packet, it retransmits two copies of # number data packet, and inserts a delay d between two consecutive copies of each # number data packet. When the transmitter receives a NACK signal

[[at]] the second time for # number data packet, it retransmits four copies of # number data packet, and inserts a delay d between two consecutive copies of each # number data packet; and so on. If the transmitter receives a NACK signal [[at]] the third time for # number data packet, it will retransmit eight copies of # number data packet, and will insert a delay d between two consecutive copies of each # number data packet (this has not been shown in the figure). Figure 3 shows at the second time of retransmission, its third copy is received correctly.

Obviously, for the exponential increase scheme the number of copies ~~copy number~~ is increased rapidly ~~along with~~ as the retransmission numbers increase, therefore efficiency is lower, but ~~it will be returned with~~ there is an improvement of a decrease of retransmission numbers and persistence time. ~~It is more adequate for the~~ This scheme is more appropriate in an environment where the channel condition is very bad and the propagation time is longer.

~~It is need to illustrate that the~~ The delay d, which concerns ~~about~~ the delay between two consecutive copies above, should optimally be a random variable. In principle, the delay should be longer than the burst channel fading period length. But it cannot be too long, because too long will increase the transmitting time of a data packet and decrease SR-ARQ performance. Nevertheless, for a time-vary channel it is a very difficult issue to define random burst channel fading period length.

Referring to figure 4, ~~it shows the~~ a method of an interleaving procedure according to the invention is shown, which is used to solve a problem ~~about~~ of inserting delay between every copy of the same lost data packet. Before interleaving, there are 3 copies, &l, &l, &l, of #1 data

packet, 2 copies, &2 &2, of #2 data packet and 2 copies, &3 &3, of #3 data packet queuing in sequence in the queue. There is no delay between copies of the same data packet, the sending principle is first-in-first-out. After interleaving, between every & copy of the same # number data packet, one copy of two other # number data packets is inserted. For example, between every two copies of &l, a copy &2 and a copy &3, two copies in total, are inserted, between two copies of &2, a copy &3 and a copy &l, two copies in total, are ~~insert~~ inserted, between every two copies of &3, a copy &l and a copy &2, two copies in total, are inserted. It is formed that the delay time is 3, between every copy of same data packet.

In principle the interleaving method of the present invention is ~~same as the~~ similar to interleaving ~~method~~ in channel coding, but in the present invention the interleaving object is data packets and not bits, furthermore only the multiple copies of the retransmitted lost data packet are interleaved, and the interleaving is before retransmission. It is interleaving transmission. Figure 4 shows after interleaving, multiple copies, belonging ~~belong~~ to the same lost data packet, are transmitted in sequence after delay. The delay time is the time length of the number of different sequence number data packets queuing in the interleaving queue. If the burst channel fading period length is long, then the number of different sequence number data packets queuing in the interleaving queue is more and the delay is longer.

Figure 5 shows an ~~the first~~ embodiment for the scheme of interleaving retransmission in the invention. The transmitter needs to set three queues, including transmission queue, retransmission queue and buffer queue. The transmission queue, marked with #, is used to store new transmitting data packets. The retransmission queue, marked with &, is used to store

multiple copies of specific data packets needed to be retransmitted. The buffer queue, which does [[is]] not belong to the scheme of the invention, is used to store the data packets having been transmitted but without receiving the acknowledgement signal. Suppose that #6, #7 and #8 are arranged in sequence from queue head in the transmission queue. In retransmission queue there are arranged in sequence with two copies, &l, &l, of #1 data packet, two copies, &2, &2, of #2 data packet, and three copies, &3, &3, &3, of #3 data packet. It is known from the retransmission queue that the number of different retransmitted packets is 3. In the retransmission queue, the number of the same data packet copies is acquired, first according to the current retransmission number then calculating with the linear increase principle or exponential increase principle, all the copies of same data packet are stored continuously.

In step 1, at first it is necessary to determine whether the retransmission queue is empty or not; if the retransmission queue is empty, every data packet in the transmission queue is transmitted according to the first-in-first- [[--]] out principle; if the retransmission queue is not empty, then it enters the interleaving transmission state.

Entering the interleaving transmission state is implemented by setting the length of the interleaving retransmission interval. In order to control the minimum value of multiple copies transmission delay for specific data packet, the minimum value d_s of interleaving retransmission interval length should be set (it can be determined by the specific mobile communication system). In the figure, two conditions are set, they are $d_s=5$ and $d_s=1$, respectively. The length of the interleaving retransmission interval is a value which should be chosen as ~~choose~~ the largest one among the minimum value (d_s) of the interleaving retransmission interval length and

the maximum value of number (in the figure example it is 3) of different data packets in retransmission queue.

In step 2, interleaving transmission is proceeded, it is started to form every interleaving retransmission interval.

When d_s=5, the timer is set to 5. From the retransmission queue, one copy of every retransmission data packet is selected, &1, &2 and &3, and they are transmitted by the first-in-first-out principle. When the transmission is finished, and if the timer is not over, ~~so~~ then data packets #6 and #7, in the transmission queue, are transmitted by the first-in-first-out principle, until the timer is over, the first interleaving retransmission interval is ended. At this moment, if the retransmission queue is not empty, the next interleaving retransmission interval is started. Again, from the retransmission queue, one copy of every retransmission data packet is selected, &l, &2 and &3, and they are transmitted by the first-in-first-out principle. When the transmission is finished, and if the timer is not over, [[so]] continuously data packet #8, in the transmission queue, is transmitted; when it is finished, and if the timer is not over, [[so]] stop transmission until the timer is over, the second interleaving retransmission interval is ended. At this moment, if the retransmission queue is still not empty, the next interleaving retransmission interval is started. Again, from the retransmission queue one copy of #3 data packet, &3, is selected and transmitted; when it is finished, and if the timer is not over and the transmission queue is empty, [[so]] stop transmission until the timer is over, the third interleaving retransmission interval is ended. As the retransmission queue is now empty, the interleaving transmission will be ended,

with first-in-first-out principle, new data packet transmission in transmission queue is started (if there are new data packets in the transmission queue).

When $d_s = 1$, the timer is set to 1. From the retransmission queue, one copy of every retransmission data packet is selected, &l, &2 and &3, and they are transmitted by the first -in-first-out principle; When the transmission is ended the timer is over, so the first interleaving retransmission interval is ended. Because the retransmission queue is not empty, the next interleaving retransmission interval is started. Again, from the retransmission queue, one copy of every retransmission data packet is selected, &l, &2 and &3, and they are transmitted by the first-in-first-out principle; when the transmission is finished, the timer is over, so the second interleaving retransmission interval is ended. At this moment, the retransmission is still not empty, so the next interleaving retransmission interval is started. Again, from the retransmission queue one copy of #3 data packet, &3, is selected and transmitted; when it is finished, the timer is over, so the third interleaving retransmission interval is ended.

In step 3, when the retransmission queue is empty, the interleaving retransmission state is ended; with the first-in-first-out principle, data packets in the transmission queue are transmitted. As shown in the figure when $d_s = 1$, after the third interleaving retransmission interval is ended, it is started to transmit data packets in transmission queue, #6, #7, and #8.

Two real examples in figure 5 show that the length of the interleaving retransmission interval is the retransmission delay of multiple copies of every lost packet. In reality, the length of the interleaving retransmission interval is determined by d, and the number of lost data packets;

$d_s = 1$ is a special case, the length of interleaving interval is only determined by the number of successively lost packets.

With reference to figure 7, in reality, the interleaving retransmission procedure of the invention is using the number of continuously lost packets in the last transmission to predicate the length of current channel fading period. In an ideal case, the length of channel fading period is unchanged, only one time of interleaving retransmission is needed, i. e. every lost data package needs to transmit only two copies.

Figure 7 shows that when the number of continuously lost ~~packet in~~ packets in the last transmission is 4 (#3, #4, #5, #6), the length of predicting channel fading period is 4. After one time of interleaving retransmission, that is every lost data packet only transmits two copies, &3, &4, &5, &6 and &3, &4, &5, &6, the receiver receives the retransmission data packets &3, &4, &5, &6 successfully.

Therefore, the value of the timer is decided, based on the number of continuously lost packets in the last transmission or based on the measurement result of the technique by which the fading pitch is measured.

Referring to figure 6, it shows ~~the second~~ another embodiment of the method for multiple copies plus delay retransmission scheme of the invention. It is a multiple queues polling retransmission method. Compared with the ~~first~~ embodiment[[,]] shown in figure 5, the interleaving transmission method shown in fig. 6 is different.

The transmitter also needs three queues, including transmission queue, retransmission queue and buffer queue. The transmission queue is used to store new data packets to be transmitted. The retransmission queue is used to store multiple copies of every specific data packet needed to be retransmitted. The buffer queue is used to store the data packets having been transmitted but without receiving the acknowledgement signal ~~(it is not belong to the scope of the invention scheme)~~.

When the retransmission queue is not empty, it enters an interleaving retransmission state, polling transmission is started.

Step 1. Set N individual copy queues, the sequence numbers are copy queue 1, copy queue 2, copy queue 3, ... , copy queue i, ... , copy queue N, one copy of every specific retransmission packet will be stored in each copy queue in sequence. For example, two copies of #1 retransmission data packet, &l and & 1, are stored in copy queue 1 and copy queue 2, respectively, two copies of #2 retransmission data packet, &2 and &2, are stored after copy &l, in copy queue 1 and copy queue 2 respectively; three copies of #3 retransmission data packet, &3, &3 and &3, are store, after copy &2, in copy queue 1, copy queue 2 and copy queue 3 respectively. This means if a retransmission data packet has k individual copies, then the k copies are stored in copy queue 1, copy queue 2, ... , copy queue k, respectively.

Step 2. ~~Start~~ Starting from copy queue 1 to copy queue N, they are transmitted in sequence. Then, if any copy queue is not empty, it will start again from copy queue 1 to copy queue N

transmitted in sequence until all the copy queues are empty, and the polling transmission procedure is ended. When transmitting, only after the current copy queue is empty, then the next copy queue can be transmitted. This means only when the i^{th} copy queue is empty, then the $(i + 1)^{th}$"" copy queue can be transmitted. Furthermore in spite of whether there is any empty copy queue from i^{th} copy queue to N^{th} copy queue in real, it must be transmitted in sequence until the N^{th} copy queue.

Step 3. When all N individual copy queues are empty, the polling transmission procedure is ended, and transmitting new data packet in the transmission queue is started. Considering that in many mobile communication systems, the numbers of retransmission are controlled in real operation, for example, in IS-99, the numbers of retransmission cannot exceed 3. This means that in one retransmission, the copy number will not exceed a certain fixed value. If using the linear increase method of the invention, then in one retransmission the copy number [[is]] does not exceeded 4. If using the exponential increase method of the invention, then in one retransmission the copy number [[is]] does not exceeded 8. When using the ~~second embodiment the~~ polling transmission of multiple queues, the number of copy queue can be set respectively as 4 and 8, and the implementing procedure will be greatly simplified.

Therefore, ~~under~~ when limiting the numbers of retransmission, the effect of the second ~~kind~~ method, polling retransmission method, is same as the first ~~kind~~ method with $d_s = 1$, but the implementation of polling retransmission method is simpler ~~more simple~~.

Reference is now made to figure 8, figure 9 and figure 10. Under the conditions of a 20 db signal-to-noise ratio (S/N), and different channel fading speed f_d (Hz), such as 5 Hz (represented by triangle), 10 Hz (represented by lozenge) and 50 Hz (represented by *), with an emulation approach, ~~there~~ shown are the result of the relationship between delay time (T^{delay}) and effective throughput, delay time (T_{delay}) and the mean of the number of retransmissions, and delay time (T_{delay}) and variance of the number of retransmissions, respectively. In the figures, ~~colored thread~~ a solid line represents Delay-Linear-Multiple-Copies-Retransmission scheme, dot dash line represents Delay-Exponent-Multiple-Copies-Retransmission scheme.

The figures show that slow fading speed will lead to decreased throughput, increase mean of the number of retransmission and variance of the number of retransmission. This is because slow fading speed has a larger correlation and longer fading period length, which ~~increase~~ increases the probability of successive lost packets ~~packet~~.

Besides, directing to the traditional Selective Retransmission (SR) scheme, the Delay-Linear-Multiple-Copies-Retransmission (D-Linear-MCR) scheme and the Delay-Exponent- Multiple-Copies-Retransmission (D-Expo-MCR) scheme, it can further be ~~acquired~~ seen the influence of channel round trip time to effective throughput, mean of number of retransmissions and variance of number of retransmissions. The result is that: along with increased round trip time, the Delay-Multiple-Copies-Retransmission scheme of the invention will get better performance. This is because after passing a longer round trip time, the correlation of successive retransmission is ~~decrease~~ decreased.

In addition, also directing to the traditional Selective Retransmission scheme, the Delay-Linear-Multiple-Copies-Retransmission scheme and the Delay-Exponent-Multiple-Copies-Retransmission scheme, with different channel fading speed (as 10 or 100Hz), it can also be ~~acquired~~ seen the influence of signal-to-noise-ratio (SNR-db) to effective throughput, mean of number of retransmissions and variance of number of retransmissions.

The result is: along with the decrease of signal-to-noise-ratio, especially when the signal-to-noise-ratio is less than 25 ~~dB~~ db, the performance of delay multiple copies retransmission is decreased greatly.

Figure 11 is a simulation curve diagram of transmission performance improvement according to the method of the invention. In a typical mobile communication system, emulating different ARQ schemes, the performance of Transfer Control Protocol (TCP) have been acquired. In emulation, the following conditions are taken:

The capacity of wired network is 100Mbps;

The capacity of wireless link is 2Mbps;

The propagation delay of wired network is 50ms;

The propagation delay of wireless network is 10ms;

The link layer packet size is 53 bytes;

The TCP packet length is 576 bytes;

The buffer in the base station can store at most 384 link layer packets;

The maximum times of retransmission are 2 (copies are 3 or 4);

The minimum value of interleaving retransmission interval d_s is 1;

Two state Markovian model is used to simulate fading channel.

Figure 11 compares the end-to-end TCP throughput of different ARQ schemes ~~scheme~~. The X-axis represents channel fading speed f_d (Hz), and the Y-axis represents throughput. The dot line connected with hollow lozenge blocks, shows the ideal state without limiting numbers of retransmission (unlimited retransmission). The solid line connected with solid square blocks, shows performance of traditional selective retransmission (SR-ARQ) scheme. The solid line connected with solid lozenge blocks, shows performance of Linear-Multiple-Copies-Retransmission (Linear-MCR) scheme. The solid line connected with + symbol, shows performance of Exponent-Multiple-Copies-Retransmission (Expo-MCR) scheme. The solid line connected with solid triangle shape, shows performance of Delay-Linear-Multiple-Copies-Ret (D-Linear-MCR) scheme. The solid line connected with + shape, shows performance of Delay-Exponent-Multiple-Copies-Retransmission (D-Expro-MCR) scheme. The results show: the invention scheme compares with traditional SR-ARQ scheme, a better TCP end-to-end throughput can be acquired. Experience also shows performance of the D-MCR scheme is better than MCR scheme, while different multiple copies schemes (Linear and ExPro) have no much difference.

In general, in the fast fading channel, because the mean lost rate of data packets is higher, performance of the Exponent scheme is better than the Linear scheme, throughput is large. But in the slow fading channel, longer fading period length will greatly decrease the effectiveness of the multiple copies scheme, so at the lower effective throughput condition, throughput of the

Exponent scheme will be lower than the Linear scheme. Therefore, it should select different multiple copies scheme for different requirement.